

Portable ultrasound on deployment: a pilot study

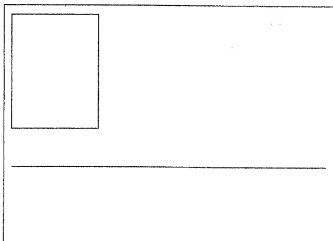
Use of the SonoSite 180 ultrasound device on deployment with 2 Health Support Battalion in East Timor

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DEPLOYED MEDICAL UNITS of the Australian Defence Force have historically not had access to sophisticated radiological investigations such as ultrasound and computed tomography. There have been several reasons for this, including the military requirement for mobility, the operator requirement that investigations be easily performed, and the surgeon's requirement only to use information gained appropriately within the limitations of the mission. In short, technology has not been able to provide a small, lightweight, sturdy imaging device which can provide useful clinical information to units in the field.

The SonoSite 180 portable ultrasound machine (cost: about \$40 000) is a recent development in ultrasound technology, allowing all the features of a larger "traditional" ultrasound machine to be miniaturised into a portable, 2.4 kg backpack-sized machine (see Box 1). Previously, portable machines were far too heavy, and unwieldy, to be deployable. These machines would not stand the wear and tear of movement in containers, aircraft or trucks. The SonoSite 180 potentially avoids all these problems, providing for the first time a truly lightweight ultrasound device. Indeed, it is my understanding that significant funding was supplied by the US Department of Defense to assist in the development of such a machine. In addition, advances in technology have allowed high quality images to be produced on a relatively small screen.

The purpose of this pilot study was to assess this new technology in the conditions of a deployed field hospital, namely the United Nations Hospital in Dili, East Timor.



Abstract

Aim: To assess the suitability of portable ultrasound, specifically the SonoSite 180 machine (SonoSite Inc, Bothell, WA, USA) for use in deployed medical units of the Australian Defence Force.

Methods: During deployment to East Timor a SonoSite 180 was used on surgical patients presenting to the UN Hospital in Dili. Patients were both general surgical referrals and trauma patients.

Results: The SonoSite 180 proved itself to be portable, robust and suitable for use in relatively austere environments. On average the ultrasound was used once every three days. Of the nine patients examined, in no cases were results misleading, in four no further information was gained, and in five further information was gained which positively influenced management.

Conclusions: The SonoSite 180 shows definite potential to positively influence the management of patients in the field environment, both as a triage tool and in reducing unnecessary evacuation of patients out of the area of operations.

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Methods

A SonoSite 180 machine was purchased for evaluation by Defence National Stores Distribution Centre after Australian Defence Medical Ethics Committee approval and issued for my use, during my specialist rotation to the UN military hospital in Dili, East Timor.

I have previously used a larger Toshiba ultrasound machine (Box 2) to evaluate trauma patients as part of my duties as Trauma Fellow at Royal Melbourne Hospital. I have had limited formal training in ultrasound, including introductory courses as part of trauma training. As the surgeon deployed to the UN military hospital in Dili, I had clinical responsibility for the management of trauma and general surgical patients.

The machine was kept in my possession at all times, stored in air-conditioned rooms but used on an opportunity basis in all areas of the hospital. I performed all examinations and interpretations of the images.

Results

The tabulated data for all investigations is shown in Box 3.

I The SonoSite 180

The SonoSite 180 system is a portable, software-controlled ultrasound system. It has an all-digital architecture. It can be used to acquire and display high-resolution, real-time and Color Power Doppler ultrasound images. The system has cine-review, image zoom, labelling, measurement and calculations, image storage and review, printing and recording capabilities. It supports a variety of transducers for abdominal, gynaecological and obstetric applications. Probes can be readily replaced allowing rapid repair, even in remote locations. It can be connected to external monitors, video printers and video cassette recorders, and therefore has telemedicine capability.¹

Specifications

Height: 33.8 cm

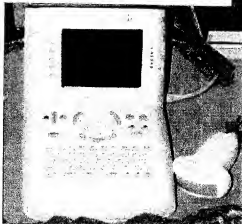
Width: 19.3 cm

Depth: 6.35 cm

Weight: 2.4 kg

Imaging modes include 2D Imaging (256 grey shades) and Color Power Doppler Imaging (64 colours). It can store up to 50 Images.

Temperature and humidity limits are quoted for storage and shipping, and for operating.¹ The high range for operation is 40°C, 95% humidity — conditions not dissimilar to the extremes found in East Timor, and Northern Australia.



The hepatorenal angle (Morrison's pouch) as imaged by the SonoSite.

Portability

The SonoSite was used in the resuscitation area, general ward, and intensive care unit of the hospital, and was operated under both battery and mains power. The machine was easily carried from place to place, and could be taken to patients, rather than bringing patients to a central location, saving time and inconvenience to ward staff and patients.

Clinical utility

Nine examinations were performed for a variety of problems, from abdominal and soft tissue investigations to trauma examinations. In five cases the examination added to or confirmed information and positively influenced the management of the patient, preventing unnecessary evacuation from the area of operations for further investigation. In five examinations the results were non-contributory, and management was not changed. In no circumstances was the examination incorrect or misleading.

The SonoSite contributed to the management of both medical and surgical problems, including assessment of splenic size, assessment of breast lumps, screening for gallstones and duplex scanning of the lower limbs for deep vein thrombosis. These, in addition to its role in trauma management, obstetrics and assessment of musculoskeletal injuries, give the SonoSite a wide range of applications, limited only by the operator's expertise and the mission requirements.

Ease of operation

I have had limited experience with ultrasound outside its use in trauma. However, I found the machine intuitive and easy to use. Clearly, an experienced ultrasonographer, if available,

could provide much more information to the treating doctor from the device.

Robustness and durability

The machine arrived in Dili through the normal stores system, packed in its original packing. After rapid assembly it functioned immediately. Subsequently, there were no problems with function, but it was not dropped or stored for long periods in containers, as much hospital equipment is. The brief period of the study meant that the durability of the machine was not adequately assessed, and further assessment during the remainder of the UN deployment is recommended.

Discussion

The usefulness of abdominal ultrasound in the early assessment of trauma patients is well documented in medical literature.^{2,4} Especially in the unstable patient, ultrasound offers rapid, non-invasive confirmation of the presence of intraperitoneal fluid/blood, and can quickly assess the pericardium for fluid, and exclude tamponade as a cause of hypotension. Traditionally, diagnostic peritoneal lavage and computed tomography (CT) have been used in this situation. However, despite their many positive qualities, these tests have some drawbacks.^{2,6} Diagnostic peritoneal lavage is invasive, and its sensitivity for blood is so high that it may result in non-therapeutic laparotomy, with possible unnecessary morbidity.⁷

CT is generally only suitable for haemodynamically stable patients and in trauma circles is known as the "tunnel of death" for good reason. Using CT in unstable patients requires maximal anaesthetic, surgical and intensive care support in

tertiary hospitals, and in austere environments with limited manpower such use would be inappropriate. Portable CT scanners are available in the US and in European armed forces, but not in mobile, relatively lightly scaled surgical facilities such as those deployed by the ADF.

In trauma patients the presence of intraperitoneal or pericardial blood is enough evidence to proceed to emergency surgery, and ultrasound gives precisely this information. There is good evidence that surgeons can perform ultrasound in trauma as accurately as a formally trained radiologist, with sensitivity of 93.4%, specificity of 98.7% and accuracy of 97.5%.⁸⁻¹¹ and formal management protocols for the use of ultrasound in trauma have already been developed in American trauma centres.¹²

In peacekeeping deployments, where treatment of childbearing women is commonplace, provision of ultrasound would allow easy confirmation of fetal heart rate and fetal position, and could also be used in other roles, such as the assessment of abdominal problems in both adults and children. Ultrasound has been used in the management of hydatid disease on peacekeeping missions,¹³ and has been proposed for measuring cardiac output in the field.¹⁴

Successful clinical experience of using ultrasound in a civilian facility in a war zone has already been reported.¹⁵ The SonoSite 180 was trialled in Kosovo in 1999 by the United States military, and, although no results have been published, the device has recently been allocated a NATO Stock Item (NSN) number.¹⁶

2 A typical "mobile" ultrasound machine (Toshiba), clearly unsuitable for field use



In Dili, I used the SonoSite 180 on average once every three days, suggesting that there is a clinical need for such a device on deployments. Ultrasonography in the field may in some circumstances provide rapid diagnosis and treatment of problems within the area of operations, thus avoiding evacuation. This conforms to the stated mission of the Health Services to preserve manpower within the area of operations, and would provide a considerable cost saving in avoiding unnecessary strategic aeromedical evacuation for diagnostic tests alone.

The SonoSite's portability lends itself to use in a variety of situations. Its use has already been reported in rotary wing aeromedical evacuation. It does not interfere with communications within helicopters and pilots reported no effects on avionics in any flight mode.¹⁷ It could also prove useful in the primary casualty reception facility on HMAS MANOORA and HMAS KANIMBLA, as well as in Hercules C130 aircraft during strategic international retrievals. Images could be transmitted by telemedicine for interpretation ashore.

As with all new equipment, the results gained are only as good as the operators using the equipment. Who then is best qualified to perform and interpret ultrasound? There is no doubt that those most skilful at interpreting ultrasound are radiologists. However, there are no radiologists on the posted strength of Level 3 medical units, or, for that matter, very few in uniform. (A military specialist radiologist was temporarily deployed to 3 Health Support Battalion at the Level 3 facility in Dili from the end of June to August 2001, and has continued evaluation of the

3 Ultrasound examinations carried out using the SonoSite 180 at the UN military hospital, Dili, East Timor

Patient	Sex	Age	Indication	Examination	Result	Action
1	M	22	Right iliac fossa pain	Abdominal	No contribution to management	Appendectomy
2	F	24	Left iliac fossa pain	Abdominal	Normal ovaries and kidney	Evacuation to Darwin
3	M	21	Splenomegaly	Abdominal	Spleen 10.5 cm diameter	Observe
4	M	37	Motor vehicle accident	Focused abdominal sonogram for trauma	No free fluid	Died
5	M	21	Splenomegaly	Abdominal	Spleen 10.4 cm diameter	Observe
6	F	42	Left breast lump	Breast	4.5 cm cystic lesion	Review in Darwin
7	F	34	Abdominal pain, biliary?	Abdominal	Normal, no gallstones	Tinidazole
8	M	32	Calf swelling, possible deep vein thrombosis	Doppler	Flow in popliteal vessels	Nil
9	M	35	Epigastric pain	Abdominal	Normal	Nil

SonoSite.) Clearly, if we are to move forward in provision of ultrasound, then training appropriate staff is a priority.

In practical terms, radiographers trained in ultrasonography perform most investigations in civilian practice, while radiologists interpret hard films, and consult on difficult cases. It makes sense therefore to provide trained radiographers on long-term deployments such as OP TANAGER. In fact the 2 Health Support Battalion radiographer was trained in ultrasound but did not deploy due to illness.

Some surgeons and emergency physicians are trained in the use of ultrasound in trauma cases. Many vascular surgeons perform Doppler ultrasound studies themselves, and some hold formal qualifications. Obstetricians are also trained in the use of ultrasound in assessment of their patients. It would seem appropriate to credential such specialists to use the SonoSite 180 in their area of proven expertise, and to provide general training to all military surgeons in the performance of the focused abdominal ultrasound in trauma (FAST) examination.

Training for trauma ultrasound is well established, as described by Shackford et al.¹⁰ Training includes a monitored schedule which involves eight hours of formal training and performing 50 normal scans and 20 positive scans. Credentialing is achieved after review of scans by a radiologist, and correlation with the operator's reports. An operator is credentialled if he/she has an error rate of 8% or less. If not successfully credentialled, the training process is repeated.

Conclusions

A four-week trial in East Timor by a single operator suggests that the SonoSite 180 ultrasound machine would be valuable for routine use within field medical units providing a Level 3 capability. This includes forward surgical troops (light and heavy), health support battalions, strategic retrieval teams and the primary casualty reception facility. The SonoSite 180 should only be used by those experienced in its use, in the fields in which they have expertise. Documentary evidence of training should be required.

The SonoSite 180 should be located central to the resuscitation and theatre areas. In the current configuration of 2 Health Support Battalion, the intensive care unit would be most appropriate, with the radiology department being next best.

The SonoSite 180 provides valuable clinical information currently not available to medical officers on deployments, and has the potential to preserve manpower in the area of operations by reducing evacuations for further investigations, thus conforming to the stated mission of the Defence Health Service.

4 The SonoSite machine, packed and on the move



Acknowledgements

This project was undertaken while the author was working as trauma fellow at the Royal Melbourne Hospital, and draws on research currently being undertaken in that hospital's trauma department. The author acknowledges the work of his predecessor, Mr C.K. Reddy, and the support of Associate Professor P. Danne, Director, Trauma Services, Royal Melbourne Hospital.

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